Improving Markets for the Efficient Integration of Distributed Renewable Resources

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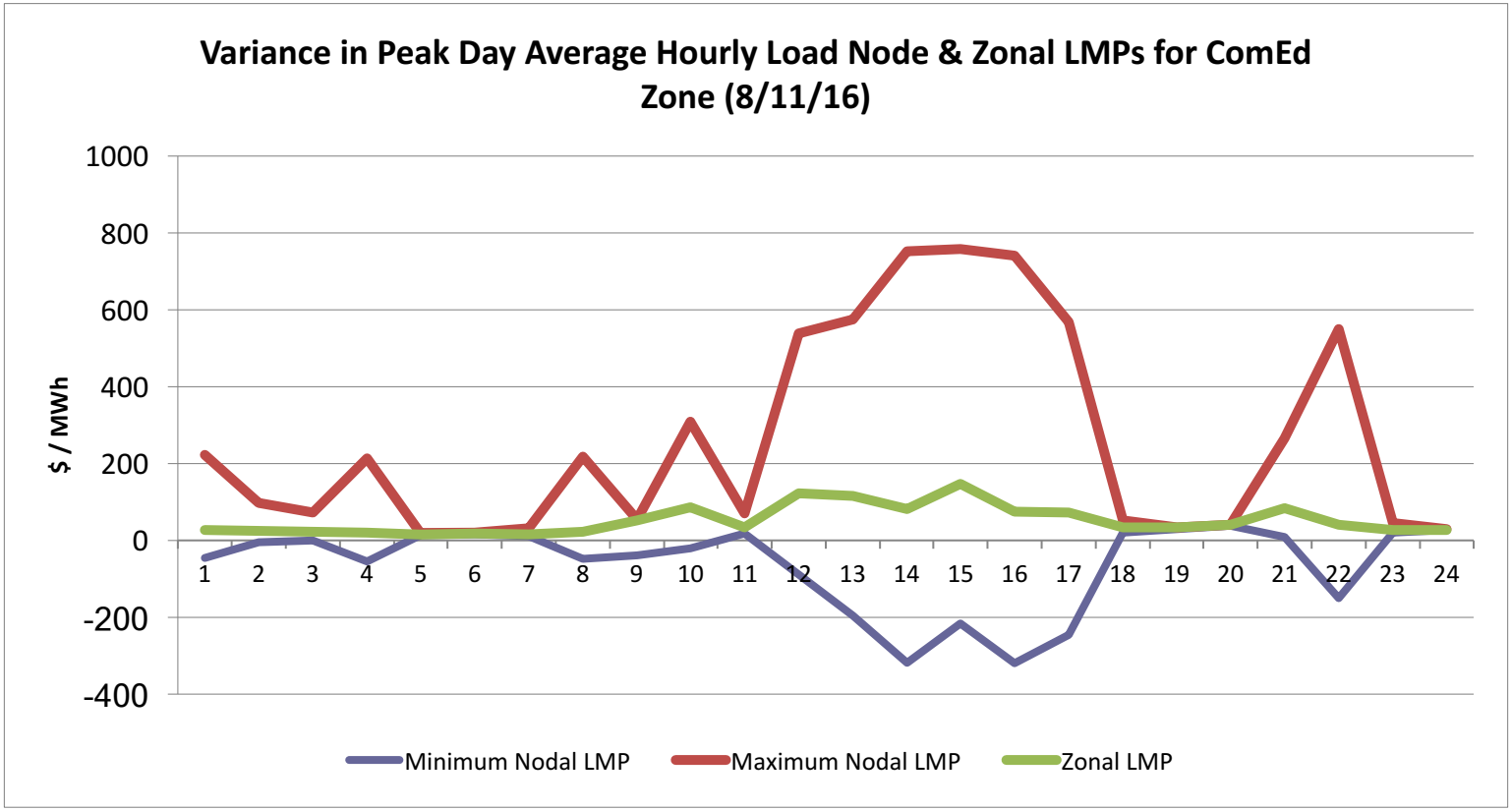
Integrating Distributed Renewables: Efficient Pricing

- Increasingly Granular Time-, Location-, & Product-Specific Pricing
- Scarcity Pricing: Customer Value of Reliability
- Distributed Intelligence: Responses to Efficient Pricing
- Pricing Carbon

RTO Settlements Lack Efficient Granular Price Signals

- Demand (& Non-aggregated DER) Settle at **Average Hourly Zonal Prices**



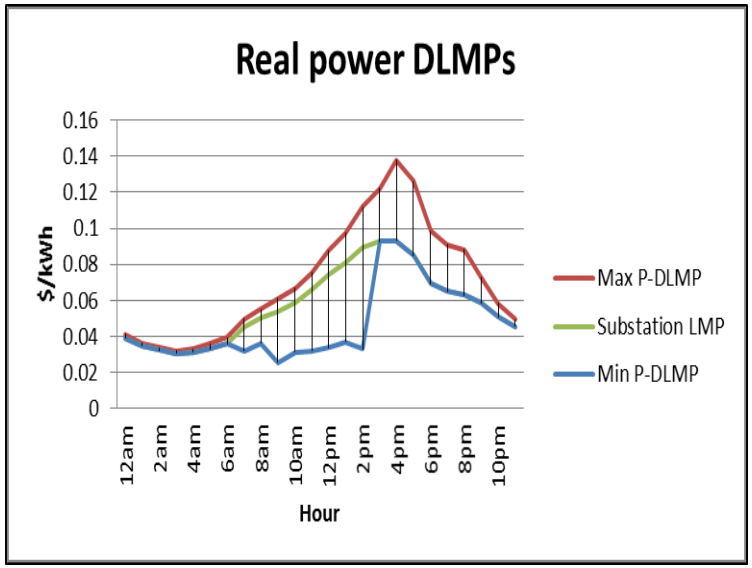
- Hides large price variances between load nodes
- Price swings suggest interval to interval variances are likely to be significant
- ***Nodal and Interval pricing of Demand is Foundational for the Valuation of Distributed Resources*** [1]

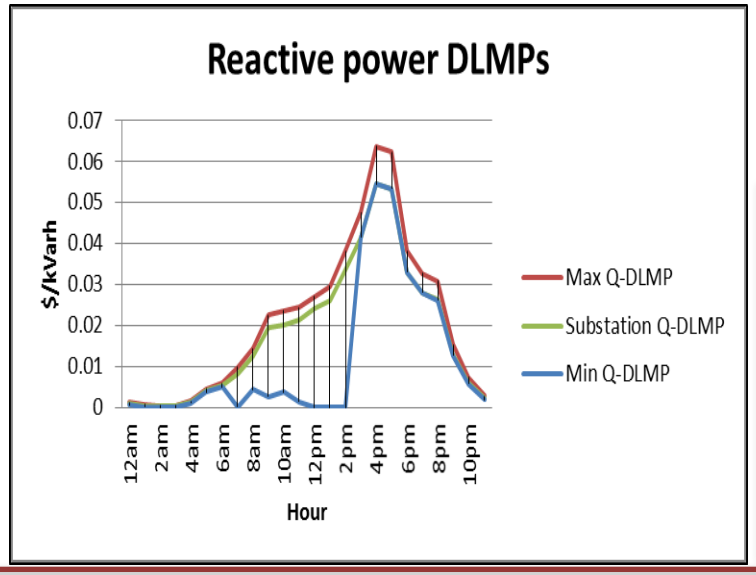
Distribution Issue: Varying Time, Location, & Product Value

- Three Products in AC Grid: Real Power, Reactive Power, & Reserves
- DER Tradeoff: Unit of Capacity Generally Can Provide Only 1 at a Time

N.Y. REV Modeling Results:

Summer Day, High DER Scenario for an Illustrative 800 Bus Commercial / Residential Distribution Feeder [1]

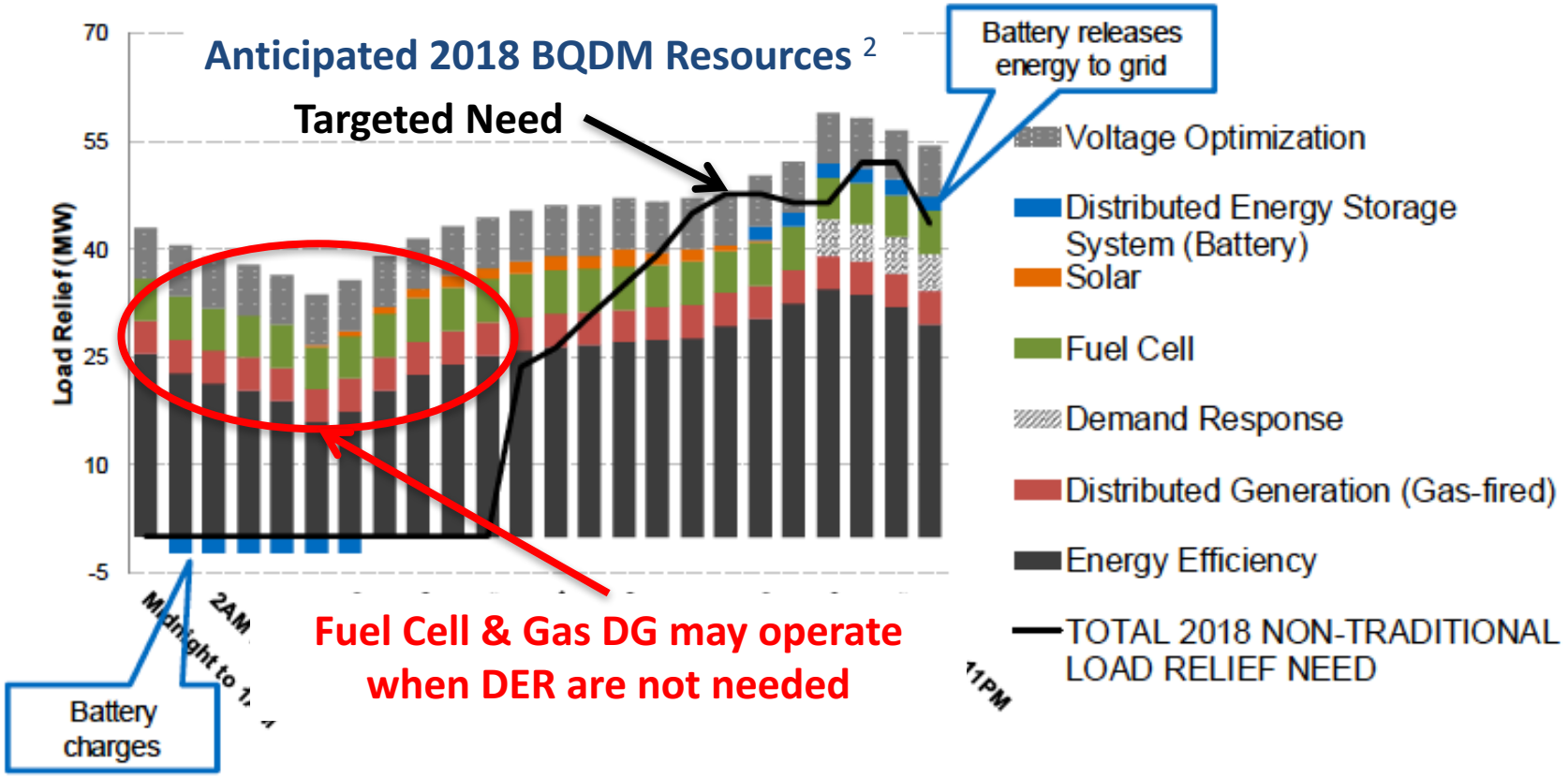




- **Cost of EV charging 42% lower**
- **Cost of Commercial Space Conditioning reduces 12% with 20% flexible demand**
- **PV revenue increases 6% with reactive power sales**

No Single Distribution Value (Value of D)

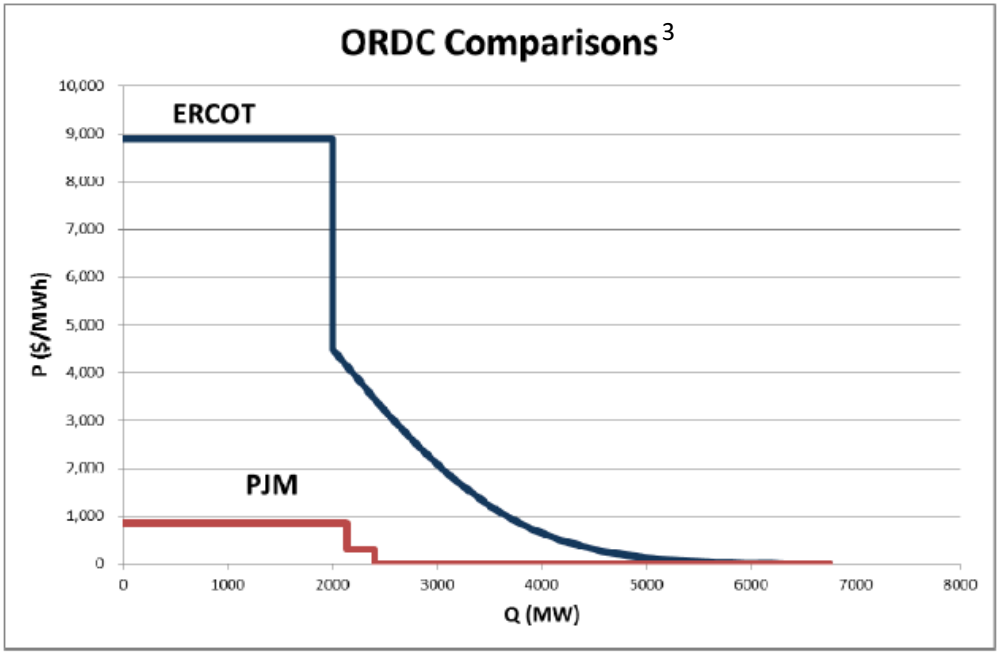
- In some cases, DER can defer more expensive distribution investments
- Efficient forward contracting requires multi-layered, location-specific forecasts
- DER that reduces costs in some hours may be uneconomic at other times



Consider Variable Time- & Location-Specific Rebates & Dispatchable Option Contracts

Scarcity Pricing: Customer Value of Reliability

- Reliability Value of Resource Adequacy is Time and Location Specific
- Operating Reserve Demand Curve (ORDC) can reflect Reliability Value to Customer
  - At minimum reserve levels, ORDC sets Reserve Price = Customer Value (VOLL)
  - At higher reserve levels, ORDC sets Reserve Price = VOLL x Probability of Service Interruptions
- PJM Shortage Pricing is Not Based on Customer Value

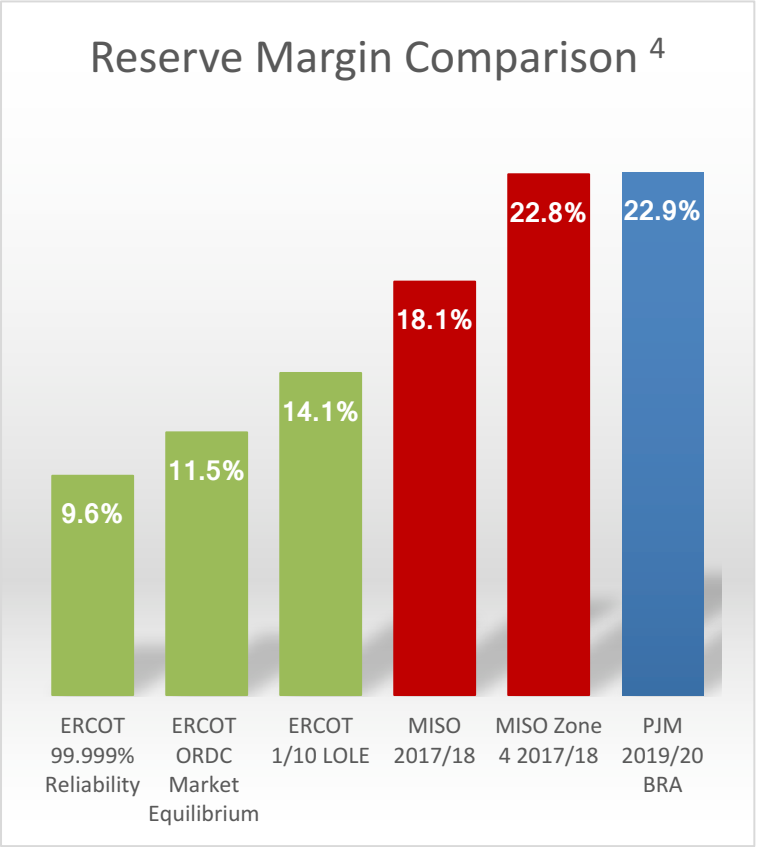


Efficient Scarcity Pricing:

- ***Reflects Time- & Location-Specific Reliability Value of Resources***
- ***Can Animate Responsive Demand***

Capacity: Understanding Missing Money

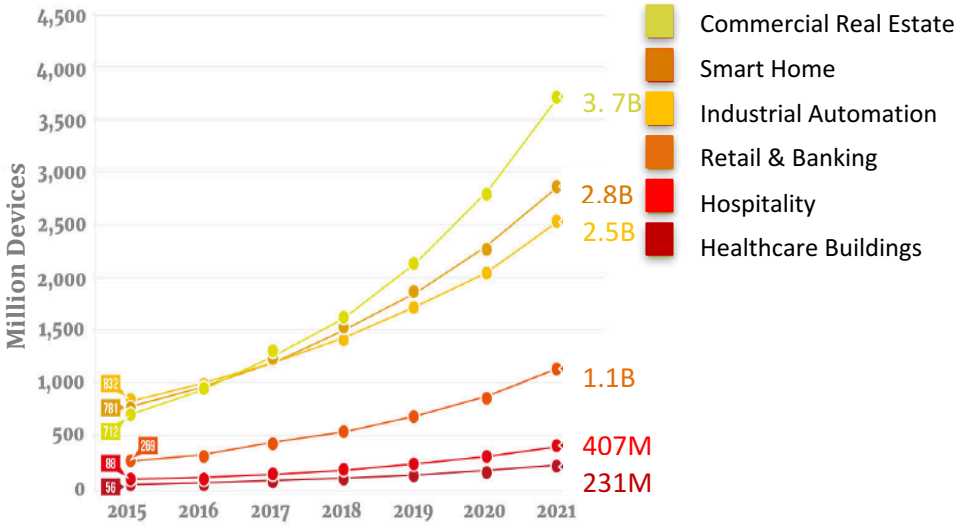
- Capacity: Imprecise Reliability Measure
  - RPM is an Administrative Mechanism, Not an Efficient Two-Sided Market
- RTO Capacity Requirements based on 1 in 10 Year Loss of Load Expectation
  - First reference to 1 in 10 LOLE in 1940s
  - No Clear Economic Basis for 1 in 10 LOLE
  - LOLE Definitions Vary and Do Not Consider Quantity of Load Interrupted
- Issue: With 90%+ of Service Interruptions typically related to Distribution Outages, High Capacity Requirements May Be Distorting Reliability Investments



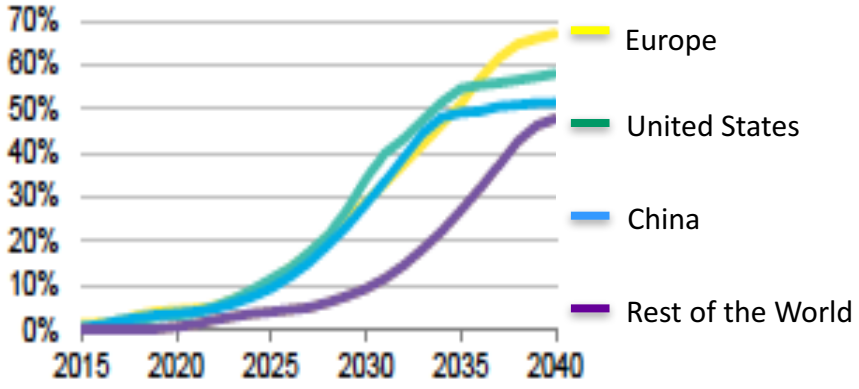
Integrating Distributed Intelligence

- Rapid Growth in Smart, Price Responsive Demand
  - Internet of Things leverages Thermal Inertia in Buildings
  - Unsubsidized EVs: Potentially cost competitive by 2025
- Objective of Efficient Pricing & Settlements in Wholesale Markets: Animate Utilities and Retail Suppliers to Compete to Help Customers their Manage Demand & Total Energy Costs
- Smart Devices Continuously seek to Optimize based on Anticipated, Real-time, Location-specific Prices

5X Increase in Smart Building Connected Devices by 2021 [5]



New Car Sales: Percent Electric Vehicles [6]

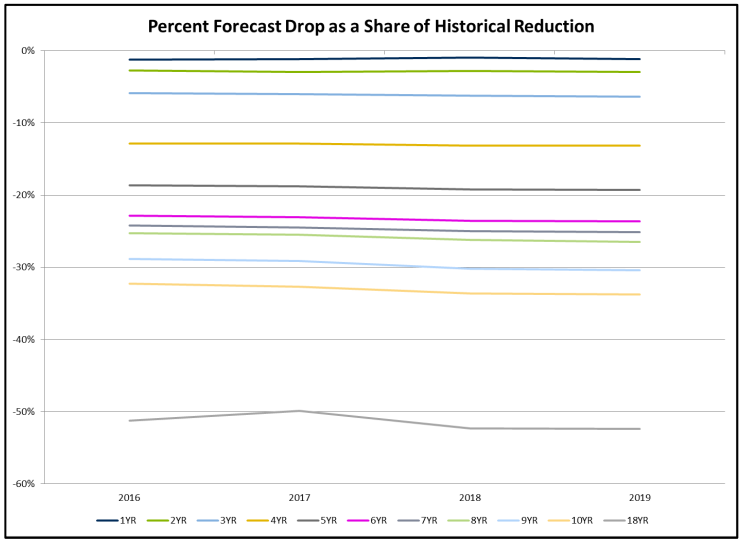


Source: Bloomberg New Energy Finance

Recognizing the Response to Efficient Prices

- DR programs not designed to support adoption of smart devices – DR relies on:
  - Dispatch: Becomes computationally Intractable
  - Reduction from Baseline: Smart devices always optimizing based on relative price differentials
- Given PJM forecasting, actual reductions in peak demand have limited impacts on capacity requirements
  - Reductions on 10 Coincident Peak days for 18 consecutive years to produces only 50% reduction in forecast capacity requirements [3]

Reduction in PJM Zonal Load Forecast As a Percent of Peak Reductions [7]



- Centolella & Ott PRD Proposal: Recognition of Price Responsive Demand
  - Use in system planning and operations, … ***forecast demand response curves that reflect a statistically predictable relationship between prices and demand***;
  - Implement an ***Operating Reserve Demand Curve with an appropriately high price***;
  - Set capacity and planning reserves for forecasted firm demand, ***after accounting for expected Price Responsive Demand*** [8]
- Altered in Stakeholder Process: Imposed Requirements Comparable to a Supply Resource, despite the Lack of any Wholesale Market Payment

Pricing Carbon

- Most studies agree that pricing carbon would reduce greenhouse gas emissions more cost-effectively than a Renewable Portfolio Standard [9]
  - An RPS fails to recognize other actions that could reduce emissions, treats all renewables as if they had equivalent impacts on system emissions, and does not reflect emissions costs in prices
- Regional Market in which Some States Price Carbon appears to be Technically Feasible [10]
  - Preventing "Leakage" – shifting of generation to non-carbon constrained states – Requires an Import Charge & Export Credit at the Seam
    - Leakage solution needs to be consistent with Economic Dispatch and Avoid altering bidding incentives so as to create "Pay as Bid" outcomes
    - Requires a One-Stage Solution – Not the 2-Stage Proposal being studied by CA ISO
  - Additional Analysis Required

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